PHORESIS BETWEEN THE SNAIL *OXYTREMA (=ELIMA) CARINIFERA* AND AQUATIC INSECTS, ESPECIALLY *RHEOTANYTARSUS* (DIPTERA: CHIRONOMIDAE)[1]

William S. Vinikour[2]

ABSTRACT: Insects, especially the midge *Rheotanytarsus*, were found to be phoretically associated with the snail *Oxytrema (=Elimia) carinifera.* Maximum incidence (82.5%) and density ($\overline{x}$ = 2.4 midges/snail) occurred at a shaded headwater site. This association provided the midge with food resources through its filtration of organic matter suspended by the snail. The midge optimized filtration by orientating its tube opening toward the aperture of the snail. This association also provided the midge with a measure of protection from sedimentation, dislodgement, and predation. Rarely, the midge *Thienemanniella,* the blackfly *Simulium tuberosum,* and the hydroptilid *Ochrotrichia* were observed as phoronts of *Oxytrema.* Their low incidence (< 0.5% per species) indicates a nonselective colonization of the snail over other available substrates. *Rheotanytarus* may be unique among the midges in its preferential phoretic association with snails, especially in less suitable habitats.

Symbiotic relationships between aquatic insects and gastropods were first noted by Barnard (1911). Other authors have reported similar associations (see Steffan, 1967) These relationships involve parasitism of the snail by dipterans of the families Chironomidae and Sciomyzidae. Only recently have phoretic associations (nonparasitic relationships in which one species lives on another to obtain transportation) between snails and insects been reported. These associations have invariably involved the midge *Rheotanytarsus* Bause (Diptera: Chironomidae) occurring on pleurocerid snails (Mancini, 1979; White et al., 1980). This study also reports on the occurrence of *Rheotanytarus* as a phoront of snails and provides an interpretation of the nature of this association. Additionally, other insect species are reported as phoronts of snails for the first time.

Study Site and Methods

I collected snails of the species *Oxytrema (=Elimia) carinifera* (Lamarck) (Gastropoda: Pleuroceridae) from three sites in the upper reach of Davis Creek, Tuscaloosa County, Alabama. Pertinent physicochemical parameters associated with each site have been presented by Vinikour (1982). Sampling was conducted on 14 March and 17 June 1981. Snails

[1]Received February 12, 1982

[2]Argonne National Laboratory, Land Reclamation Program and Division of Environmental Impact Studies, Argonne, Illinois 60439.

were hand-collected, and attempts were made to obtain a random sampling of a full range of snail sizes. In the laboratory the number of *Rheotanytarsus* (as indicated by numbers of tubes) and other insects associated with each snail was determined under a dissecting microscope. All midges encountered within the tubes were mounted for identification, and predominant gut contents were noted. The length of each snail was measured to the nearest 0.05 mm with dial calipers. A total of 679 snails were examined.

Results and Discussion

The percent infestation[3] and mean number of *Rheotanytarsus* occurring on snails for each sample site and date are given in Fig. 1. Midge infestations were highest at the headwater site (DV-01). Combining the data for the two sampling dates, I found that 75.2% of the snails at DV-01 harbored *Rheotanytarsus,* while infestaton rates at the other sites were much lower (7.2% at DV-02 and 6.0% at DV-03). White et al. (1980) observed that 80% (36 of 45) of the pleurocerid *Elimia acutocarinata* harbored *Rheotanytarsus;* Mancini (1979) routinely observed 35% infestion of the pleurocerid *Goniobasis semicarinata* at two of the three sites he studied, with the highest infestation rate being 56%.

In my study, the mean number of midges per snail for the combined dates was highest at DV-01 (1.9), compared to only 0.07 at DV-02 and 0.06 at DV-03. If only infested snails were considered, the mean number of midges per snail was 2.5 at DV-01 and 1.0 at both DV-02 and DV-03. Multiple infestations were common at DV-01, with 69% (161 of 233) of the infested snails harboring two or more midges. Most infested snails harbored from one to four midges, but one snail had ten midges (see Fig. 1). In instances of heavy infestations, some of the the individual midge tubes were constructed on top of each other (see Fig. 2). White et al. (1980) observed 89% (32 of 36) of infested snails to have multiple infestations of two to four midges; Mancini (1979) only found ≅ 10% of infestations to be multiple, although he did collect one snail with seven midges.

Mancini (1979) found that mature specimens of *Goniobasis semicarinata* tended to harbor more midges than did immature specimens. To determine whether the size of *Oxytrema* governed infestation by *Rheotanytarsus,* I conducted t-tests comparing the length of infested and uninfested snails from DV-01 for each sampling date. For the March collection, the mean length of the infested snails (13.55 mm) was significantly greater than that for uninfested snails (11.40 mm). This is mainly attributable to the fact that

[3]The term "infestation" is used in this paper to denote the nonparasitic occurrence of *Rheotanytarsus* on snails.

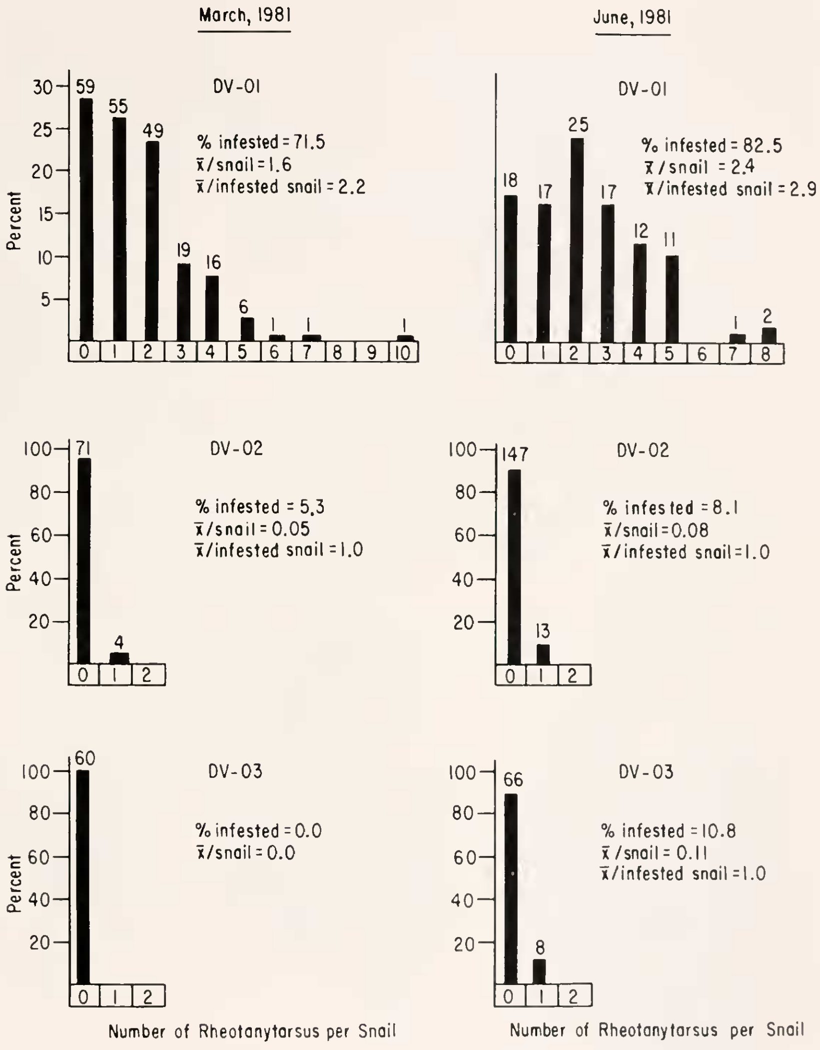

Figure 1. Percent infestation and density of *Rheotanytarsus* on *Oxytrema carinifera*. The number above each bar is the number of snails. Sites DV-01, DV-02, and DV-03 are 0.6, 4.7, and 12.8 km downstream of the headwater of Davis Creek, respectively.

most (13 of 17) snails less than 8 mm long harbored no midges. For the June collection, no significant difference in mean shell length was found between infested ($\bar{x}$ length = 13.65 mm) and uninfested ($\bar{x}$ length = 13.50 mm) snails. In part this was because the mean snail length in June (13.61 mm) was significantly larger than the mean length in March (12.87 mm). Only four snails <8.0 mm long were collected in June. A larger shell length provides greater surface area for colonization by midges. This partly accounts for the percent infestation, the mean number of midges per snail, and the mean number of midges per infested snail at DV-01 being greater in June than in March (see Fig. 1).

Also, recruitment of midges that occurred prior to the June collection would account for the insignificant difference in mean size between infested and noninfested snails in June, and for the higher incidence and density of infestation in June compared with March. Many of the midges encountered in the June collection were early instars. Smaller midge size accompanying early instar recruitment would readily allow habitation upon smaller snail shells. In contrast, most midges in the March collecion were later instars, and therefore the size of their tubes either precluded their occurrence on smaller snails or, less often, resulted in there being room for only one midge on a snail (see Fig. 2). However, significant differences between mean snail length and the number of midges per snail were not observed, as midges would also construct tubes on top of each other (see Fig. 2). Therefore, multiple infestations were not constrained solely by the amount of snail-shell surface area available for colonization.

Both Mancini (1979) and White et al. (1980) concluded that the occurrence of *Rheotanytarsus* on snails is phoretic and not parasitic. The distinct filter-feeding habits of *Rheotanytarsus* (see Walshe, 1950) lends support to their conclusions. The gut contents of 180 midges I examined consisted predominantly of sand and diatoms, with no indication of animal tissue. White et al. (1980) believed that the phoretic association between *Rheotanytarsus* and snails in their study area may have resulted from the snail shell being an easier attachment site for the midge than rough rock surfaces. However, the site at which I found the highest incidence and density of midges on snails contained a smooth bedrock substrate. Therefore, adequate substrate attachment sites would not be limited as in the study area of White et al. (1980).

Several factors have been implicated as reasons for phoretic associations between the dipteran families Chironomidae and Simuliidae and other aquatic invertebrates. Corbet (1961, 1962) believed the *Simulium* species associate with freshwater crabs, mayflies, and dragonflies primarily for a pupation site. This was inferred from the occurrence of large larvae and pupae on the host. *Rheotanytarsus* does pupate upon *Oxytrema,* as evidenced by the fact that 13% of the midges I observed were pupae. However, I observed all larval instars on the snails, with earlier instars predominating in June due to recruitment. Furthermore, an abundance of natural attachment sites was available for midge development. Also, rather than seeking an area for pupation, *Rheotanytarsus* only adds to its tube as it develops, closing it off for pupation (Walshe, 1950).

Researchers investigating the association between *Simulium* and invertebrates (crabs and mayflies) prior to Corbet's studies (see Steffan, 1967) concluded that the blackfly derived a number of advantages, including shelter from the current, a more stable substrate in areas of erodible habitat, and/or increased access to food resources. The midge *Nanocladius* obtains increased mobility, habitat security, and protection through its phoretic association with alderflies (Gotceitas and Mackay, 1980) and stoneflies (Dosdall and Mason, 1981). Gotceitas and Mackay (1980) felt that *Nanocladius* derived a greater degree of protection from predators once it was established on the alderfly. This was due to the alterfly's position as top carnivore in the trophic structure of the community studied. Although *Oxytrema* is low in the tropic structure of Davis Creek, it

Figure 2. *Rheotanytarsus* and *Simulium tuberosum* on *Oxytrema carinifera*. Note orientation of the anterior portion of the midge tubes toward the aperture or body whorl of the snail. Also evident are how early instar *Rheotantarsus* (based on the posterior portion of the tube) orient along suture lines and that some midges construct their tubes atop other midges.

is among the largest and most abundant of the invertebrates in the stream, and the shell protects the snail from many predators. Through its association with the snail, *Rheotanytarsus* would be protected from most invertebrate predators and would be subject to predation mainly by fish and other organisms large enough to consume the snails.

Dosdall and Mason (1981) believed that the midge *Nanocladius* obtained security by associating with the stonefly *Acroneuria*, in that the stonefly, being larger and stronger than the midge, could better relocate in instances of habitat disturbance. This could be pertinent in Davis Creek, because soils in Tuscaloosa County are highly erosive and the smaller streams are subject to chronic flood scouring (Harkins, 1980). Also, the high density of snails at the study site could be a potential threat to *Rheotanytarsus* in that midges colonizing bedrock surfaces could be readily disrupted by the wanderings of the snail. Thus, a major benefit that the midge would obtain from the association would be security from the snail itself.

The phoretic association can provide a measure of protection to the midge from dislodgement and sedimentation, but such protection may be secondary to the increased availability of food to the midge (especially in less than optimal habits).

Diatoms were abundant in the gut contents of midges found on the snail at all sites. However, because of (1) dense riparian shading at location DV-01 and (2) the short stream length upstream of this headwater site, it is doubtful that diatoms would be abundant within the water column for filtration by midges. The sparsity of diatoms and other fine particulate organic matter (FPOM) in the water column at DV-01 can be inferred from the fact that while large populations of Asiatic clams (*Corbicula fluminea*) were present at DV-02 and DV-03, the species was totally absent from DV-01.

It therefore can be concluded that at DV-01, the midges obtained their food by filtration of diatom-ladened sediments suspended near the aperture of the snail during the snails' movement and feeding activities. This conclusion is supported by the fact that only eight midges were located on the dorsal side of the snail shell and that overall, 98% of the midges had their anterior tube openings oriented toward the aperture of the snail or toward the body whorl adjacent to the aperture (see Fig. 2). Such orientation is probably a behavioral modification to facilitate feeding, because material sloughed into suspension by the snail would flow directly into the capture net of the midge.

Tubes of early instar larvae were usually found along suture lines, with the anterior end directed toward the body whorl. Although such orientation would generally direct the capture net perpendicular to the line of snail movement (that is, perpendicular to snail length), the midges' filtration capabilities would not be minimized. Early instar *Rheotanytarsus* tend to have only one arm from which silk is attached (Walshe, 1950), and thus a slightly perpendicular orientation to the flow of suspended matter would actually maximize filtration potential (i.e., expose more silk strands directly to incoming flow). With a full compliment of arms (five) on late instar midges, filtration would be maximized by the anterior of the tube facing the incoming source of organic matter. This was apparent in that the body position of many late instar larvae were oriented along suture lines, but the anterior ends (especially the raised position containing the net) were turned toward the aperture. At DV-01, where instream primary production and inflow of FPOM is probably limited, the midge could obtain more food by filtering relatively concentrated quantities of sediments being continuously suspended by the snail. That *Rheotanytarsus* was attaching to the snails primarily for this feeding advantage may also be inferred from the position of the midges on the underside of the snail. This positon essentially precludes direct contact of the net with the inflowing mainstream current, thereby reducing acquisition of the mainstream drifting food resources.

It should be noted that no other invertebrates were found harboring *Rheotanytarsus* at any of the sample sites. The fact that *Oxytrema* was the only large invertebrate commonly encountered on bedrock substrates may account for this. Thus, although the association between *Rheotanytarsus* and *Oxytrema* may have been initiated through chance encounter; the midge was able to take full advantage of the association by orienting itself on the snail in such a way as to optimize its collection of food, as described in the preceding discussion.

Two factors may account for the high incidence of *Rheotanytarsus* on snails at DV-01 and the low incidence at DV-02 and DV-03. The first is that *Rheotanytarsus* densities were low at DV-02 and DV-03. Samples taken at DV-02 indicate that *Rheotanytarsus* densitites were less than 10 per square meter, compared to potential densities at DV-01 of $\geq$ 4,000 per square meter (based on estimated snail densities and mean number of midges per snail). Low *Rheotanytarsus* densities, coupled with high densities of *Oxytrema*, at DV-02 and DV-03 would result in both the low observed incidence and low density of midges on snails.

The other factor accounting for the low incidence of *Rheotanytarsus* on snails at DV-02 and DV-03 is that both the quantity of FPOM and instream primary productivity are likely higher at those two sites than at DV-01. These increases result from the amplification of upstream input sources associated with extended stream reach distance and from enhanced sunlight penetration from an open canopy associated with broader stream widths. Thus, food resources available to the midge are increased at downstream reaches to the extent that the feeding advantage gained by associating with the snail at DV-01 is diminished at DV-02 and DV-03.

Other aquatic insects phoretically associated with *Oxytrema* were the midge *Thienemanniella,* the blackfly *Simulium tuberosum,* and the hydroptilid caddisfly *Ochrotrichia.* The single specimen of *Thienemanniella* encountered was found to be inhabiting a vacated *Rheotanytarsus* tube. Mancini (1979) observed a similar situation with an unidentified beetle larva inhabiting an empty midge tube. Only two pupae and one vacated pupal cocoon of *Simulium* were observed. As concluded by Corbet (1961, 1962), such an association between blackflies and other invertebrates is probably formed as a means for the blackfly to obtain an adequate pupation site. The two *Ochrotrichia* larvae encountered probably associated with *Oxytrema* for a similar reason. White and Fox (1979) found pupae of the hydroptilid *Oxyethira azteca* phoretically associated with the dragonfly *Macromia georgina* due to lack of adequate pupation sites (e.g., vegetation and rocks) normally utilized. The low incidence of *Thienemanniella, Simulium,* and *Ochrotrichia* on *Oxytrema* (mean per species <0.5%) indicates a nonselective colonization of snails over the other available substrates.

Most authors have concluded that phoretic associations involving aquatic insects are relatively common (Roback, 1977; Mancini, 1979; White et al., 1980). The specific relationship involving *Rheotanytarsus* and snails appears to be geographically widespread — such associations have been reported from Indiana (Mancini, 1979), South Carolina (White et al., 1980), and Alabama (this study). Although *Rheotanytarsus* is widespread, it may develop a high incidence of association with snails only within restricted areas of a given locality where substrate and/or food resources are inadequate. Due to its use of capture nets to filter food, *Rheotanytarsus* may be unique among the Chironomidae in its preferential phoretic association with snails, especially in less suitable habitats.

ACKNOWLEDGMENTS

This work was performed under the auspices of the U.S. Department of Energy, Contract W-31-109-Eng-38. I would like to thank Tom Daniels and Pete Prodin for field assistance. I am grateful to Dr. Carol B Stein of the Ohio State University Museum of Zoology for determination of the snail species and to Karla Vocke for photography. I also appreciate the reviews and comments of Drs. Richard V. Anderson and Robert W. Vocke and the editorial assistance of John DePue.

LITERATURE CITED

Barnard, K.H. 1911. Chironomid larvae and watersnails. Ent. Monthly Mag. 22: 76-78.

Corbet, P.S. 1961. The biological significance of the attachment of immature stages of *Simulium* to mayflies and crabs. Bull. Ent. Res. 52: 695-699.

1962. Observations on the attachment of *Simulium* pupae to larvae of Odonata. Ann. Trop. Med. Parasitol. 56: 136-140.

Dosdall, L.M. and P.G. Mason. 1981. A chironomid (*Nanocladius Plecopteracoluthus*) *branchicolus:* Diptera) phoretic on a stonefly (*Acroneuria lycorias:* Plecoptera) in Saskatchewan. Can. Ent. 113: 141-147.

Gotceitas, V. and R.J. Mackay. 1980. The phoretic association of *Nanocladius (Nanocladius) rectinervus* (Keiffer) (Diptera: Chironomidae) on *Nigronia serricornis* Say (Megaloptera: Corydalidae). Can. J. Zool. 58(12): 2260-2263.

Harkins, J.R. 1980. Hydrologic assessment, Eastern Coal Province Area 23, Alabama. U.S. Geological Survey, Water-Resources Investigations Open-File Report 80-683, 76 pp.

Mancini, E.R. 1979. A phoretic relationship between a chironomid larva and an operculate stream snail. Ent. News 90(1): 33-36.

Roback, S.S. 1977. First record of a chironomid larva living phoretically on an aquatic hemipteran (Naucoridae). Ent. News 88: 192.

Steffan, A.W. 1967. Ectosymbiosis in aquatic insects. Chapter 4. In S.M. Henry (ed.). Symbiosis. Academic Press, New York and London, pp. 207-289.

Walshe, B.M. 1950. Observations on the biology and behavior of larvae of the midge *Rheotanytarsus*. J. Quekett Microscop. Club. 3:171-178.

White, T.R. and R.C. Fox. 1979. Chironomid (Diptera) larvae and hydroptilid (Trichoptera) pupae in phoretic relationship on a macromiid (Odonata) mymph. Notul. Odonatol. 1(4): 76-77.

White, T.R. J.S. Weaver, III, and R.C. Fox. 1980. Phoretic relationships between Chironomidae (Diptera) and benthic macroinvertebrates. Ent. News 91(3): 69-74.

Vinikour, W.S. 1982. Eastern Project. Aquatic ecosystems subproject: Macroinvertebrate and fish species distribution within small order streams variously impacted by coal mining. Annual progress report. Land Reclamation Program, Argonne Nat'l. Lab., In press.

INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE

c/o BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, LONDON, SW7 5BD

ITZN 11/4 16 June 1982
(A.N.(S.) 122

The Commission hereby gives six months notice of the possible use of its plenary powers in the following cases, published in the *Bulletin of Zoological Nomenclature*, volume 39, part 2, on 15 June 1982, and would welcome comments and advice on them from interested zoologists. Correspondence should be addressed to the Secretary of the above address, if possible within six months of the date of publication of this notice.

Case No.
327 Revived proposal for the suppression of the Aphid names of Rafinesque under the plenary powers (Insecta, Hemiptera, Aphididae).

Continued on page 179